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AQUATIC PESTS ON IRRIGATION SYSTEMS

IDENTIFICATION GUIDE

A Water Resources Technical Publication

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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AQUATIC PESTS ON IRRIGATION SYSTEMS

IDENTIFICATION GUIDE

A WATER RESOURCES TECHNICAL PUBLICATION

BY N. E. OTTO AND T. R. BARTLEY
ILLUSTRATED BY D. W. CUNNINGHAM

U.S. DEPARTMENT OF THE INTERIOR
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BUREAU OF RECLAMATION
ELLIS L. ARMSTRONG, *Commissioner*

As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities for water, fish, wildlife, mineral, land, park, and recreational resources. Indian and Territorial affairs are other major concerns of America's "Department of Natural Resources."

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PREFACE

Extensive infestations of obnoxious plants and a few aquatic animals cause problems on irrigation systems, such as reduction in carrying capacity of the system, increased evaporation and seepage, clogging of structures, and water loss through transpiration. Because of the many problems created by these growths, steps are usually necessary to control them or prevent their occurrence.

The methods employed to control these plants and animals differ widely due to differences in the organisms, such as growth habitat, organism metabolism, size, growth stage, and genetic characteristics. Correct identification of the organism is therefore important to the proper control recommendation.

This simplified identification guide was prepared in response to requests from irrigation project operators and other personnel involved with biological problems requiring identification aids. It consists essentially of an illustration and a narrative description of some of the commonly observed organisms that become pests in the operation of irrigation systems in the Western United States. Not all animal pests that inhabit irrigation systems are included because many of these common ones such as muskrat, certain fish, and crayfish are readily recognizable by irrigation operating personnel. Also, many ditchbank weeds have been omitted because of the numerous species involved and the availability of a number of publications which adequately describe them.

The narrative descriptions have been written primarily for use by Bureau of Reclamation field personnel directly concerned with the problem, and they are not taxonomic descriptions of the species. The illustrations include drawings of the entire organisms, with inserts to depict key identifying features. Living material was used in most cases for reference in preparing the drawings. Individual species will vary in size, coloration, and other detailed features from those depicted. The overall characteristics illustrated are intended to show the field personnel sufficient features to permit a tentative identification. Should confirmation of this identification be needed, it is suggested that specimens be sent to a local experiment station or to the Chief, Division of General Research, Code D–1522, Denver, Colo., for examination.

The information used in this booklet was obtained from various sources. A considerable portion of it has been derived from aquatic weed research studies conducted by the Bureau of Reclamation in cooperation with the Agricultural

Research Service, U.S. Department of Agriculture. Information on the distribution of these aquatic pests and the problems they cause to irrigation systems has been obtained over the years through the cooperation of personnel of the Bureau of Reclamation and private irrigation districts. Many technical details of each species description and the names of aquatic organisms were obtained from authoritative references listed in the bibliography. The authors wish to thank the many individuals whose contributions have made publication of this identification guide possible.

The text was prepared by N. E. Otto and T. R. Bartley, plant physiologist and chemist, respectively, in the Division of General Research; the final review and preparation for publication were performed by E. H. Larson, Division of Engineering Support, Bureau of Reclamation, Engineering and Research Center, Denver, Colo. The illustrations were prepared by D. W. Cunningham of the Bureau's Regional office in Denver.

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SUBMERSED AQUATIC WEEDS

Submersed aquatic plants are a cosmopolitan group, representing a number of plant divisions and families. Plants grouped in the general submersed category range from primitive forms to highly developed flowering-type pondweeds that grow primarily in the water medium, including some species that develop specialized floating or emersed leaves and fruiting heads. A few representatives presented in this section might better be designated as combination submersed-emersed aquatic plants, but were included in this group because they are most troublesome when growing in the submersed form. Many of these plants are adaptable to wide variations in environment. The same species are often found growing in widely diverse situations of water temperature, quality, and velocity. Submersed aquatic plants often are able to survive periods of adverse growing conditions. This is due predominantly to prolific seed or spore production and the extensive and varied development of specialized tissue for vegetative multiplication. The submersed plants probably cause more trouble in irrigation waters than all other types of aquatic weeds. Extensive growths in distribution and drainage systems restrict the carrying capacity of canals and choke trashracks and pump inlets.

Some of the more common species of submersed plants found in irrigation systems are described to illustrate the types that may be encountered. Positive identification of some of these plants requires close examination and the use of technical botanical references.

SAGO PONDWEED

Potamogeton pectinatus L.

This pondweed has often been referred to as horsetail moss or bushy pondweed when observed growing in irrigation canals. The most widely accepted common name is "sago," meaning comblike, which is descriptive of its vegetative growth character. The species is probably the most widespread submersed aquatic weed found in irrigation canals of the Western United States. It grows in a variety of habitats from shallow, swift water to deep, still water and is often found in natural lakes, reservoirs and streams, which are the main sources of infestation to irrigation systems. The vegetative form of sago pondweed is quite variable and will differ under changes in environment. A large, vigorous form of this species is often referred to as giant sago pondweed.

This plant produces a highly branched growth of slender stems and leaves arranged in a rather fan-shaped order. The plant produces only submersed leaves that are very narrow, linear, and somewhat triangular in cross section. Leaf tips are often long, tapering to points (insert 1). Flowers and the nutlike fruits are produced in an interrupted arrangement on a long, slender, terminal stem that floats at or near the water surface (insert 2). The plant is reproduced in subsequent growing seasons primarily by the vegetative tubers and occasionally by seed. Dissemination of tubers and fragmentation of vegetative plant parts can spread the plant during growing periods. The fleshy tubers (insert 3) are produced in considerable numbers at the ends of underground stems, or rhizomes, growing at depths from a few inches to 3 feet or more in canal soil. Occasionally, tubers are produced above the soil surface in the axils of stem branches. Because of the extensive rhizome runner and tuber development of this species, a single plant spreads over a considerable area.

Potamogeton pectinatus

LEAFY PONDWEED

Potamogeton foliosus Raf.

This plant develops a dense mat of slender, horizontal stems or rhizomes near the aquatic soil surface, rooting at each stem-joint or node. The erect stems develop to varying lengths depending upon the depth of water in irrigation canals. This species derives its common name "leafy" from the extensive foliage it produces. This pondweed is commonly found in canals and drains as an early season invader and sometimes in late season, but is not as prevalent during the midsummer. This is probably due to its inability to successfully compete with the more vigorous pondweed species, such as American and sago pondweeds where they coexist, and its early age of maturity.

Leafy pondweed is completely submersed in habit, producing loose branches that present a bushy appearance with stems that seldom reach the surface in deep water. The leaf blades are narrow and flat and have a definite midrib vein that is white or yellowish in color. Flowers and fruiting spikes are produced on short stems arising from the terminals of the stems.

The plant overwinters by producing a tight, compact vegetative bud in the axils of the branches that is rather hard when mature (insert 1). These winter or axillary buds are produced in considerable quantities as the plant progresses to vegetative maturity (insert 2) and sink to the bottom when the plant disintegrates.

Leafy pondweed is widespread throughout the Western United States and is among the first pondweed species to invade an irrigation canal. It becomes overshadowed by more persistent deep-rooted pondweeds as the system ages, although it will continue to grow in association with these other species. It develops and matures rapidly during the warm summer months. Consequently, it is often found in intermittently watered canals and drains. As the plant reaches maturity, the stems fragment readily, producing considerable floating vegetation.

Potamogeton foliosus

AMERICAN PONDWEED

Potamogeton nodosus Poir.

American pondweed is commonly found growing near the shoreline of lakes and ponds. Its presence becomes very obvious by the extensive development of floating leaves in midsummer. Its specific name, *nodosus* inferring knotty, is a description apparently derived from the slight swelling at each stem-joint, or node, giving the plant stem a slight knotty appearance. This species infests laterals with low-velocity waters and the shallow areas of lakes, reservoirs, and ponds. This pondweed, although cosmopolitan in distribution, is most frequently found growing in irrigation laterals or in slow-moving water.

The mature plant produces both submersed and emersed leaves. The submersed leaves are thin membraneous structures that are long, narrow, and taper into the stem without a well-developed petiole (leaf-stem). The mature submersed leaf is usually brownish-red in color but may, in deeper water, be more of a light green.

Emersed or floating leaves are narrow-elliptical in shape, firm, and possess a definite waxy cuticle on the upper surface. Flowers are borne on a compact spike that emerges above the water surface for wind or insect pollination. Following development of the beaked nutlike fruit (insert 1), the spike turns down to submerse the maturing fruit head. The species spreads and is reproduced in subsequent seasons by long, slender buds that develop in chains on the terminals of horizontal stems (insert 2). Like sago pondweed, these vegetative winter-buds are produced in great numbers at depths of 2 to 12 inches below the surface of the aquatic soil. The winter-bud is easily distinguished from terminal shoot buds by its makeup of overlapping fleshy scales.

In growth habit, American pondweed resembles one or two other species of pondweeds. Differentiation can often be made only by the use of detailed botanical references.

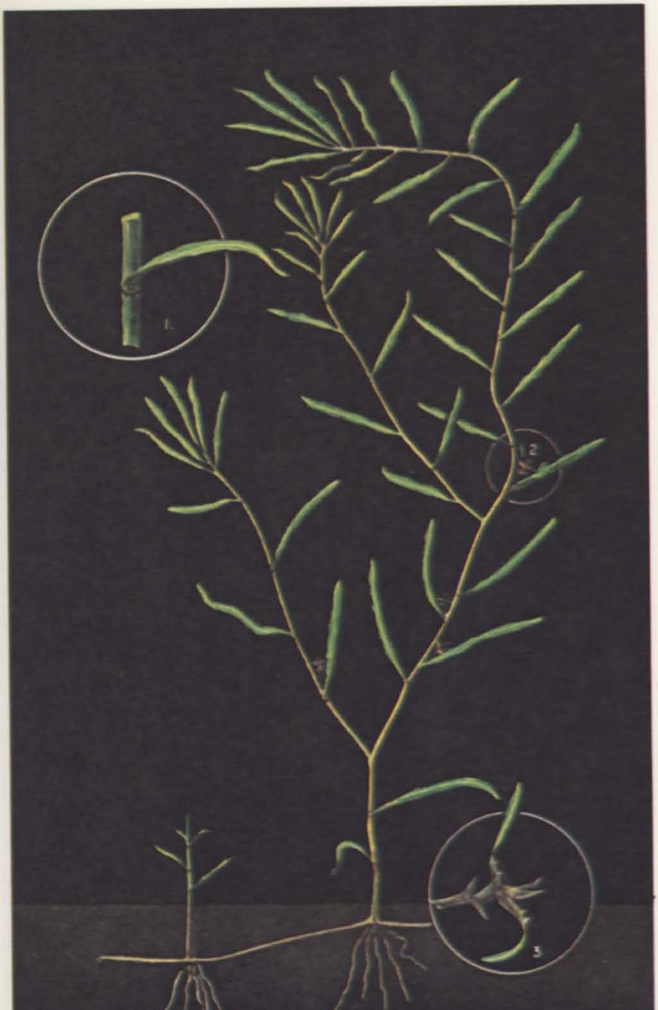
Potamogeton nodosus

CURLYLEAF PONDWEED

Potamogeton crispus L.

Curlyleaf pondweed is generally observed growing in slow-running streams or canals. This species has limited distribution in Western irrigation canals, being reported more extensively in the Central Valley of California. It is a well-marked species, deriving its specific name from the crisp nature of the mature leaves and overwintering buds. Stems of this plant are somewhat flattened (insert 1) and freely branch on the upper portions of the plant. This plant is completely submersed in growth habit, producing narrow oblong leaves with the leaf base attached directly to the main stem (sessile). The leaf margins are finely toothed, and upon maturity the margins become wavy, producing the characteristic indicated by the common name "curlyleaf pondweed."

The vegetative overwintering bud that is produced in the leaf axil (insert 2) is unique to this species and provides a means of distinct identification. This burlike winter-bud (insert 3) is commonly produced in late summer. Upon maturity of the parent plant, these hard winter-buds fall to the bottom mud, where they develop in the subsequent growing season to produce new plants.



Potamogeton crispus

RICHARDSON PONDWEED

Potamogeton Richardsonii Rydb.

Richardson pondweed is usually found growing in deeper water of lakes and slower moving streams. It has occasionally been observed in large irrigation canals, but is seldom reported as being a serious problem to water distribution systems.

This species has vegetàtive characteristics resembling those of two other pondweed species (P. *praelongus* and P. *perfoliatus*) that grow in similar habitats, and it may be a hybrid from these species. The leaf and stem growth characteristics of Richardson pondweed are quite distinct. The leaves of this plant are somewhat oval to linear, being thin and membraneous and clasping the stem at point of attachment (insert 1). All leaves are submersed and become progressively shorter toward the tip of a branch. Leaves have wavy margins and exhibit three to seven prominent veins that tend to parallel the long axis of the leaf. Stems and rhizomes are white and not spotted. Vegetative reproduction is from slender, fleshy winter-buds that develop under the soil on the terminals of horizontal stems (insert 2). These overwintering structures resemble those produced by American pondweed, but outwardly appear to be less scaly and are more fleshy and white in color.

Flowers are borne on spikes that are produced near the water surface and may emerge. The beaked, nutlike fruits are produced on the flower spikes similar to American pondweed.

This plant is widespread across the northern part of North America.


1.
2.
Potamogeton Richardsonii

WHITESTEM PONDWEED

Potamogeton praelongus Wulfen

Whitestem pondweed, or *praelongus* as it often called, is usually found in deep, cold water of clear lakes or irrigation conveyance systems near such water sources. It undoubtedly will be found more often in deeper canals, but has seldom been reported as a serious aquatic pest. The similarity of this species to a number of other pondweed species can be confusing to an identifier without examination for specific growth character.

The large white or whitish stem that quite often grows in a zigzag pattern is distinctive (insert 1). Leaves of this species are oval to linear and are similar to Richardson pondweed in growth pattern, except that *praelongus* is generally larger and produces leaves with broad bases that never clasp the stem more than halfway. All leaves are submersed and become progressively shorter toward the tip of a branch. The tips of the leaves are boat shaped. The plant is produced from stoutish white rhizomes that are covered with rusty spots.

Flowers and the strongly beaked nutlike fruits are produced on a spike that emerges above the water surface.

This species is widespread across the northern part of North America and has been reported primarily from streams and lakes in the Pacific Northwest.

Potamogeton praelongus

GIANT PONDWEED

Potamogeton vaginatus Turcz.

This pondweed is undoubtedly often mistaken for the large, vigorous form of sago pondweed that is commonly referred to as giant sago pondweed. Incorrect identification of this plant can be easily made because its vegetative growth characteristics are similar to those of sago. Only close examination can differentiate the two plants. The stems of giant pondweed are freely branching and leafy. All the leaves are submersed and are narrow-linear in shape. In general, though, the leaves and stems of this species are larger and more robust than those of sago.

There are a number of vegetative characteristics of this species that can be observed which can be used to differentiate it from other pondweeds with generally similar vegetative character. Like many organisms in nature, some of the identifying features given for giant pondweed can vary from those illustrated in this booklet. One of these which typifies the situation is the loose, leaf-sheath-like structure or stipule produced on the lower or primary leaves (insert 1) of giant pondweed; botanical descriptions indicate that this characteristic is sometimes approximated in sago pondweed. The leaf tips of giant pondweed are rather blunt and sometimes slightly notched (insert 2), unlike the sharp, tapering tip of sago. Flowering spikes of giant pondweed are more numerous and in more crowded whorls than those found on sago.

One feature that should aid materially in the identification of this species is the uniquely shaped tuber, which is much different than the sago tuber (insert 3). These tubers are produced in knotty clusters on the terminals of fleshy white underground stems.

A third pondweed species, *P. filiformis*, is closely related to both giant and sago pondweed and could be mistaken for giant pondweed. In general, *P. filiformis*, or fine-leaved pondweed, is less vigorous and has smaller leaves, stems, and tubers, although the tubers are similar to those produced by *P. vaginatus*.

Giant pondweed is seldom reported in Western irrigation systems, but probably occurs more often than suspected because of its similarity to the cosmopolitan sago pondweed.

Potamogeton vaginatus

HORNED PONDWEED

Zannichellia palustris L.

Horned pondweed is a cosmopolitan plant that is classified in a different plant genus than the other aquatic weeds referred to as pondweeds. The *Zannichellia* genus has one species only. This plant resembles sago pondweed, but upon close examination many differences can be noted. Leaves of horned pondweed are much narrower and threadlike and arranged on the stems in an opposite manner, while those of sago pondweed develop from the stems in an alternate pattern. This is a completely submersed plant that develops a dense, creeping system of horizontal stems that are shallow rooted with sparsely branching stems. It produces a dense, usually short, mass of vegetation.

The plant derives its common name from the incurving hornlike beaked fruits (insert 1) which are usually found in threes or fours with very short fruit stems (peduncles). Flowers and fruits are produced in the axils of the leaves (insert 2). Unlike true pondweeds of the *Potamogeton* genus, this plant does not produce vegetative overwintering structures and is carried through adverse growing conditions and disseminated by seed.

Horned pondweed is a widespread aquatic weed and can most often be observed in spring or early summer, preceding the growth of other more vigorous pondweeds, although it will grow in association with the true pondweeds. Horned pondweed is rather unique in that it will tolerate excessively cold water and can often be seen growing as small tufts on the bottom of streams and canals of Northern latitudes during winter months.

Zannichellia palustris

WATERWEED

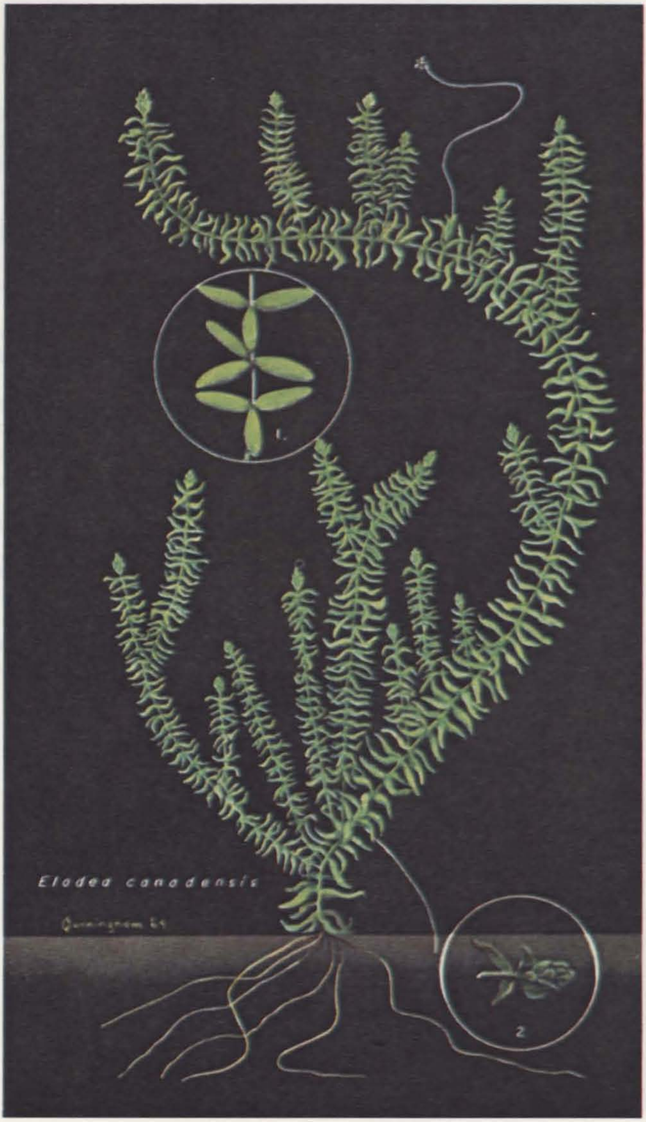
Elodea canadensis Michx.

This completely submersed plant is often seen growing in dense patches in all types of fresh-water habitats. It is commonly referred to as waterweed, water-thyme, or ditch-moss. Also, the generic name *Elodea*, a derivation of the Greek *elodes* (meaning marshy), is becoming an increasingly popular name for plants in this genus. *Anacharis* and *Philotria* are synonymous names for this plant genus that are falling into disuse. The plant is probably an escapee from ornamental culture in aquariums.

There are a number of species of this genus, but *E. canadensis* is the most widespread in irrigation waters. The vegetative growth habit is distinct, making identification of the genus quite easy. Species identification becomes more laborious but does not require detailed study. The slender stems branch readily into paired forks with whorls of leaves three or four in number at each stem node. Individual leaf bases are somewhat clasping, forming a continuous ring around the stem (insert 1). Leaf margins are small toothed. Male and female flowers are borne on separate plants. The pistillate or female plant is the one seen most often, producing leaf whorls that are more dense with shorter stem internodes than those on the male plant.

The waterweed flower is produced quite often on the end of threadlike shoots that grow to the water surface. Fruits and seeds are rare because of the scarcity of male plants. Dissemination of the plant is from vegetative buds produced on the terminal ends of shoots and by plant fragmentation. The plant overwinters by these vegetative buds that break from the stems in late summer and fall into the bottom mud (insert 2). This plant will survive and grow in a completely floating state, although it usually grows much more vigorously when rooted in soil.

Waterweed is very common to practically all areas of Western irrigation systems and can be found growing in patches in both large canals and small laterals. It will produce very dense stands in slow-moving water of canals and shallow areas of reservoirs and ponds.


Elodea canadensis
1.
2

WATERBUTTERCUP OR CROWFOOT

Ranunculus spp

Plants in this genus are not necessarily true submersed aquatics, but are amphibious, growing as well on damp soil as in the submersed condition. These plants are represented by both annuals and perennials having alternate leaves on either erect or creeping stems. Often in the emersed forms, the leaves will arise from a basal or rosettelike point of attachment. Submersed leaves are finely dissected or with divided lobes running to common points on the leaf-stem (petiole), giving the appearance of a crow's foot (insert 1) The emersed leaves, which are not always present, vary with species, and are broader and less finely divided than submersed leaves.

Flowers are produced above the water surface. The flower petals are usually yellow and rarely white. Some aquatic forms produce flowers that have white sepals (the leaflike structures on the basal portions of flowers) and yellow petals, giving the appearance of white flowers with yellow centers. Various species produce solitary flowers, while others develop in clusters. The beaked nutlike fruit pods are numerous.

Crowfoot is often found in irrigation systems, usually in clear, low-velocity waters. It seldom develops extensively enough to create a serious hydraulic problem. Waterbuttercup has been reported to be a plant indicative of good water quality, as it apparently will not tolerate adverse conditions as readily as many aquatic weed species.


1.
Ranunculus spp

COONTAIL OR HORNWORT

Ceratophyllum demersum L.

This perennial plant is found in sluggish streams and ditches and is among the dominant aquatics in temporary ponds and newly formed lakes. These are rootless plants that in early season grow upright, with the lower portion anchored in the bottom mud. During late season the plants are found floating near the surface. The finely divided leaves are produced in whorls at stem nodes. The individual leaf is cut into two to four forked divisions with occasional toothlike projections on the margins (insert 1). The stem internodes are shortened towards the tip, giving the shoot an appearance of a bushy tail, hence the common name "coontail".

Flowers and fruits are produced singularly in the axil of the leaf whorls. The fruit is rarely observed. Vegetative overwintering is accomplished by thickened and shortened shoot tips that develop late in the season and break off and sink to the bottom soil to vegetate during favorable growth periods.

This plant can be confused with certain submersed water buttercups without some scrutiny. The two plants can be distinguished by the definite whorled leaf attachment and forked divisions of *Ceratophyllum*, unlike the fan-shaped submersed leaves of buttercup.

Coontail, while not generally considered a serious submersed aquatic weed, is often seen in irrigation systems and can be an aquatic pest in small laterals and new systems.

Ceratophyllum demersum

WATERMILFOIL

Myriophyllum spp

Watermilfoil may be completely submersed with just the flowering spikes emersing, or in certain species portions of the stem and leaves may be above the surface. The stems are simple or slightly branched, and the leaves may be arranged either in whorls or scattered on the stem. The submersed leaves are usually highly dissected and comblike.

One of the more commonly observed species is the American or northern milfoil, *Myriophyllum exalbescens* Fern. Stems of this species are simple or forked, with vegetative tissue that has a brownish-purple pigmentation. The deeply dissected leaves develop in whorls of threes or fours (insert 1). The floral spike is the only plant part that emerges above the water surface. Parrot-feather, *M. brasiliense* Cambess, is a species that is occasionally seen as an escapee from aquarium culture, especially in warmer climates. This species produces emersed leaves that are featherlike and are dissected into 10 or more comblike divisions (insert 2). Flowers of parrot-feather are usually conspicuous as white tufts in the axils of the emersed leaves.

Flowers on all the species are quite small, having four petals. The fruits are nutlike bodies joined in groups of four. Certain species overwinter by means of winter-buds that develop in the leaf axils. Because of the wide variability of foliage character of plants in this genus, even on the same plant, it is difficult to separate the species. Differences can only be determined by detailed study of flowers and fruits.

Watermilfoil is a widely distributed aquatic plant that is often found on irrigation systems, particularly in still or slow-moving water. It is considered to be a pest to water distribution systems only in localized situations.


2
Myriophyllum brasiliense
1.
Myriophyllum exalbescens

WATERPLANTAIN

Alisma gramineum var. *Geyeri* Samuelsson

Plants in this family can be seen growing emersed, totally submersed, or on wet banks. The species that is illustrated produces both emersed and submersed vegetation. It is probably more commonly observed in irrigation canals as a submersed plant. Possibly when it develops the emersed form, it might be thought of as being a totally different plant.

In a submersed habit this plant produces long linear or grasslike leaves for which the specific name *gramineum*, or grasslike, is descriptive. The leaves arise from the base or crown, attaining lengths up to 3 feet. Roots of *Alisma* are fibrous and generally do not extend deep into the mud. In the emersed habit, the narrow, elliptical-shaped leaf blades emerge above the water surface supported by long, firm petioles (leaf stems).

Flowers of this plant are borne on a loose, irregular forked arrangement or loose panicle. Flower petals are white to purplish. The individual seed heads or nutlets are borne in a ring (insert 1). Differentiation between varieties of this species is made by the length of the fruiting stems, *Geyeri* having fruiting stems shorter than the leaves.

Alisma may be annual or perennial. These plants produce many viable seed that readily germinate in a wet or submersed situation. However, the seedling survival is generally low as apparently only a fraction of the germinated seedlings are able to reach maturity. Waterplantain overwinters by means of a fleshy crown or cormlike structure when exhibiting perennial growth habits.

Alisma gramineum var. Geyeri

HOLLY-LEAVED WATERNYMPH

Najas marina L.

This member of the *Naiad* family is easily recognized by its spiny-stiff leaves that resemble the leaf of holly.

Stems of this completely submersed species branch loosely near the plant base. The stem internodes are often armed with prickles. The stiff leaves are oblong to linear with coarse spiny margins, and are often spiny toothed along the back of the midrib vein (insert 1). The leaf bases are rounded and broad, forming a conspicuous sheath at the stem. Flowers and fruits of this annual plant are produced in the sheathed base of the leaf axils. The fruit is a nutlet enclosed in a loose membranelike covering that is easily separated.

Holly-leaved *Naiad,* as it is sometimes called, may be found in both deep and shallow alkaline water. It is apparently not widespread or commonly found, but has been reported as an invader in irrigation canals of the Southwest.

Najas marina

WATERSTARGRASS

Heteranthera dubia Jacq.

The leaf and stem tissue of this submersed plant could easily cause it to be mistaken for a pondweed were it not for its light yellow starlike flowers (insert 1). The star-shaped flowers are produced singularly on elongated tubelike stems that are exposed above the water surface (insert 4). Leaves of waterstargrass lack a midrib vein and are grasslike with bases attached directly to the branching stems (insert 2). The leaf sheaths are thin membraneous and tipped with small, pointed appendages (insert 3).

There is a form of this plant that produces shorter leaves and stems and grows on shallow mudbars. This form is reported to flower more often than the submersed aquatic type. The genus *Heteranthera* is sometimes commonly referred to as mud plantain, probably because of the ability of various species to survive on mudbanks.

Waterstargrass grows in both still and flowing waters. Although it is widespread in the Midwestern and Southeastern States, it is not commonly seen in Western irrigation canals. It has been reported most extensively in canals of Arizona and occasionally in California.

Heteranthera dubia

WATERCRESS

Radicula Nasturtium-aquaticum L.

Watercress is a widespread perennial herb that is seen growing on margins of small streams and shallow water areas. This particular species is the common watercress that is collected from fresh springs for salads. Because of the creeping and freely rooting stem growth habit, watercress can extend into the shallow, slow-moving water of irrigation canals and obstruct waterflows. This plant is a troublesome weed in irrigation drainage channels when not kept in check.

Watercress is quite easily recognized by its fleshy leaf structure that is made up from three to nine oval-shaped leaflets that combine to form a single compound leaf. The plant roots extensively from the prostrate stems. Small flowers with white petals are produced at the terminals of the stems. The slim fruit pod, or silique, which is typical of plants of the mustard family will be seen below the flower heads, the older ones elongating as the seeds mature.

This plant extends its growth from the shallow shore margins into the water, often completely submersed for long periods.

Species of watercress are widespread and can be expected to be found on wet areas of all Western irrigation systems although usually in localized infestations.


Radicula Nasturtium-aquaticum

TRUE MOSS

Bryophyta

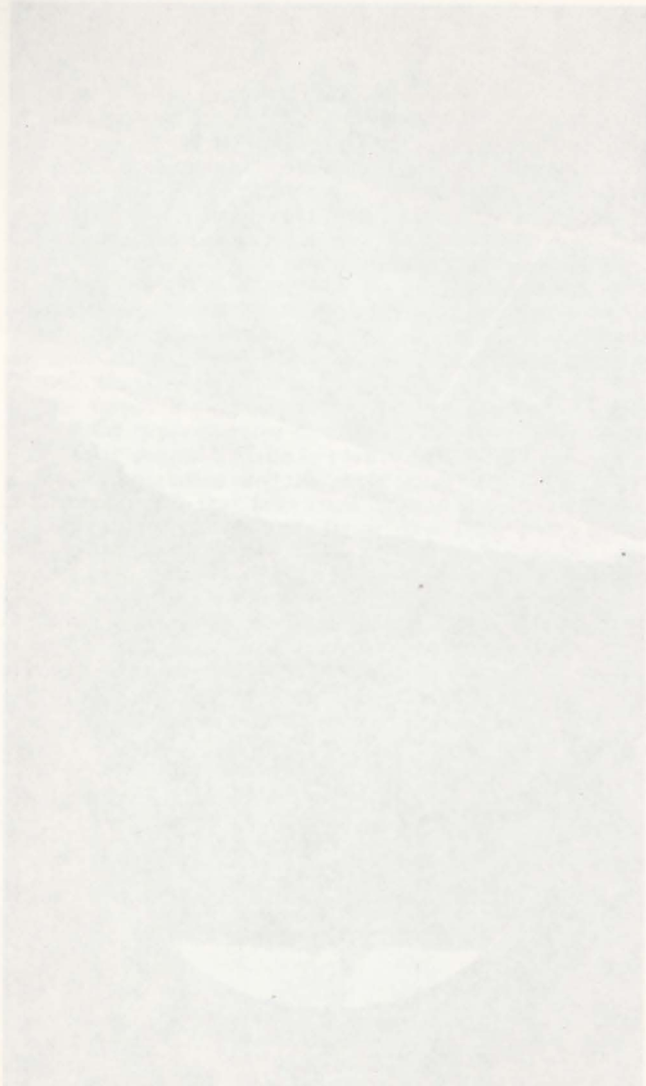
Many submersed aquatic plants are commonly referred to as moss, which is botanically incorrect and leads to confusion in obtaining information on control measures. Mosses or *Musci* (true mosses) belong to the plant division *Bryophyta* and are a higher type plant than filamentous green algae with which they are often confused.

The conspicuous plant, or gametophyte, of commonly observed mosses is differentiated into an erect central axis or stem with small spirally arranged leaves resembling those of true flowering plants. True mosses do not have roots, but are anchored to the substratum by threadlike projections, or rhizoids, that fan out from the base of the stem.

True mosses are predominantly land plants, being one of the simpler types of green terrestrial plants. A few species are aquatic or semi-aquatic in growth habit and vary in size. Generally, true moss produces short stems only a fraction of an inch in length that arise from dense mats of growth. A few representatives are much larger, producing stems up to 6 or 8 inches long.

True mosses are occasionally found growing on small areas on canal linings, often in the shaded areas, and where a thin soil substrate is available. They occasionally are reported to cause problems to water distribution systems. Two genera of mosses have been reported in Western irrigation systems, although many others undoubtedly occur. These genera are *Fontinalis*, which is one of the largest mosses, and *Fissidens*, a much smaller plant. A typical growth of the moss *Fontinalis* is shown as it might be found on a lined canal.

TRUE MOSS
Fontinalis spp



ALGAE

Algae are microscopic plants that are included in the botanical division Thallophyta, being unlike higher flowering plants in that the plant tissue is not differentiated into stems, roots, and leaves. The plant body is referred to as a thallus. Sometimes plants of this division that grow in irrigation systems are incorrectly called moss. True mosses, as previously described, are a much higher type plant.

There are a multitude of types and species of algae that grow in fresh water. The type most generally considered to be important in the operation of irrigation systems is the filamentous green algae. These are considered to be of a higher botanical type, but still are very primitive as compared to the flower-producing pondweeds.

A number of microscopic or more primitive one-celled algae (that are either unicellular or colonial) are usually found in irrigation waters and often create the problem of reducing the carrying capacity of water distribution systems. These algae range from green types to blue-green types, often causing the water to be murky or green in appearance, or produce distinctive colonies that vary widely in character. Some of these algae are responsible for odors and tastes in water and some can be toxic to animals when ingested. Certain higher forms of green algae develop a thallus that bears a certain resemblance to the leaf and stem tissue of higher plants. These plants, known as stonewarts or Chara, are discussed in a later section.

FILAMENTOUS GREEN ALGAE

Filamentous green algae present serious problems in irrigation canals by attaching to concrete canal linings, thus reducing the carrying capacity. A typical habitat sketch of attached filamentous green algae is shown in the upper portion of the illustration.

A close visual examination of these attached organisms (insert) reveals that these plant colonies are composed of masses of threadlike structures. Some species of green algae produce filaments that are coated with a gelatinous sheath, giving them a slimelike texture. Certain other species are covered with calcareous deposits that impart a rough, coarse texture. The individual plant body, or thallus, consists of a single row of cells that divide longitudinally to produce fine, green filaments. Some species develop solitary filaments, while the more complex ones are diversely branched. The filaments of certain species attach to a solid substrate, such as a canal lining, by a special cell called a holdfast.

Filamentous green algae multiply vegetatively by cell division and fragmentation of the threadlike thallus. Thick-walled microscopic spores, or resting bodies, provide a means for the plant's survival during unfavorable growing conditions and for dissemination of the species.

Identification of the individual genera of algae is often difficult and requires detailed microscopic examination. Single species of algae are seldom found growing alone in a field situation, but a number of species usually grow in association with one another. Some of the more common genera found in irrigation systems are *Stigeoclonium*, *Oedogonium*, *Ulothrix*, and *Cladophora*. Magnifications of the growth characteristics of these few genera are illustrated in the lower portion of the plate to give some concept of the cellular makeup of these microscopic plants.

Many of the filamentous green algae also will develop colonies of filaments that are free floating. These develop so extensively as to produce dense mats at or near the water surface. Usually, in these growth states, the algae become a nuisance by fouling pump inlets, irrigation siphon tubes, trashracks, and sprinkler heads.


Oedogonium
Stigeoclonium
Ulothrix
Cladophora
FILAMENTOUS GREEN ALGAE

BLUE-GREEN ALGAE

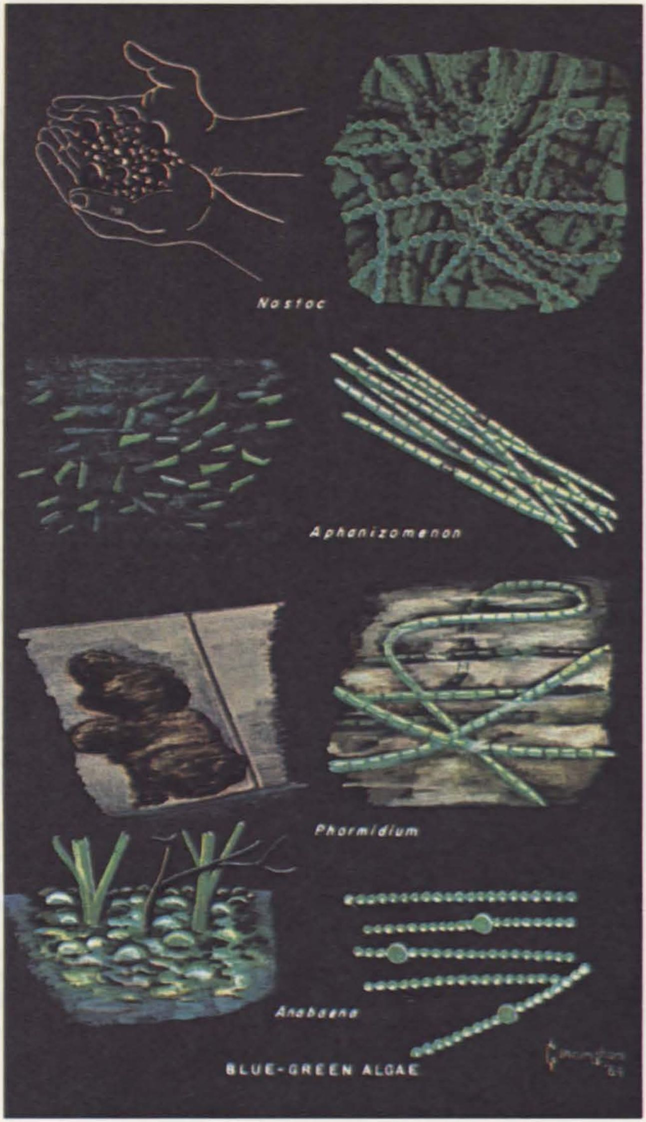
Blue-green algae are a very diverse group, being classified primarily by cell pigmentations that produce an overall blueish-green coloration to the plants. These plants, like green algae, grow as individual cells (unicellular) or in filamentous colonies, depending on genera. Many of the filamentous colonial types produce gelatinous coatings that sheath the cell walls. A number of species produce distinct colonies, such as the jelly-balls of *Nostoc* and the tough, compact mats of *Phormidium*. Blue-green algae are usually found growing in association with filamentous green algae. A few typical blue-green algae found on irrigation systems are illustrated; a habitat sketch is shown on the left and a microscopic view of the plant cells that make up the filaments on the right.

The upper left portion of the drawing shows the typical "jelly-ball" of *Nostoc*, which will be highly variable in size and is observed either free-floating or resting on the bottom of a canal or pond. These algae can cause problems in plugging siphon tubes and pumps.

The second illustration shows free-floating *Aphanizomenon* colonies. This species gives an impression of lawn grass clippings floating in water. This plant could, in certain situations, become a menace to mechanical water conveyance equipment, as well as create a taste-odor problem to potable water.

One of the blue-greens that has caused some hydraulic problems to lined conveyance channels is *Phormidium*. Colonies of this species can become fixed to a canal lining and produce thick, tough, gelatinous masses, thus not only reducing the capacity of the channel but causing fouling of pumps, hydroelectric generators, and siphon tubes as the mats break apart.

The lower illustration is *Anabaena*, a species that can, upon decomposition, produce taste-odor problems as well as soluble substances that can be toxic if ingested in quantity by mammals. This is a very common species frequently found floating on the water surface in dense gelatinous masses that have a rather moldy appearance.


Nostoc
Aphanizomenon
Phormidium
Anabaena
BLUE-GREEN ALGAE

STONEWORTS

Chara spp and *Nitella* spp

This is an interesting family of plants represented by the most common genera *Chara* and *Nitella*. These plants are universally recognized as being related to green algae, but technically there exists a diversity of opinion by botanists as to the degree of relationship.

These gray-green plants are more highly developed vegetatively as compared to most other fresh-water algae. They grow submersed in fresh water upon muddy or sandy bottoms, thriving best in clear, hard waters.

This family of algae is unique in that the plant body or thallus is characterized by a branched erect stem that has cylindrical whorls of branches at regular successions along the stem. Each stem node bears these leaflike branches that give the plant the general appearance of being a higher or flowering-type plant.

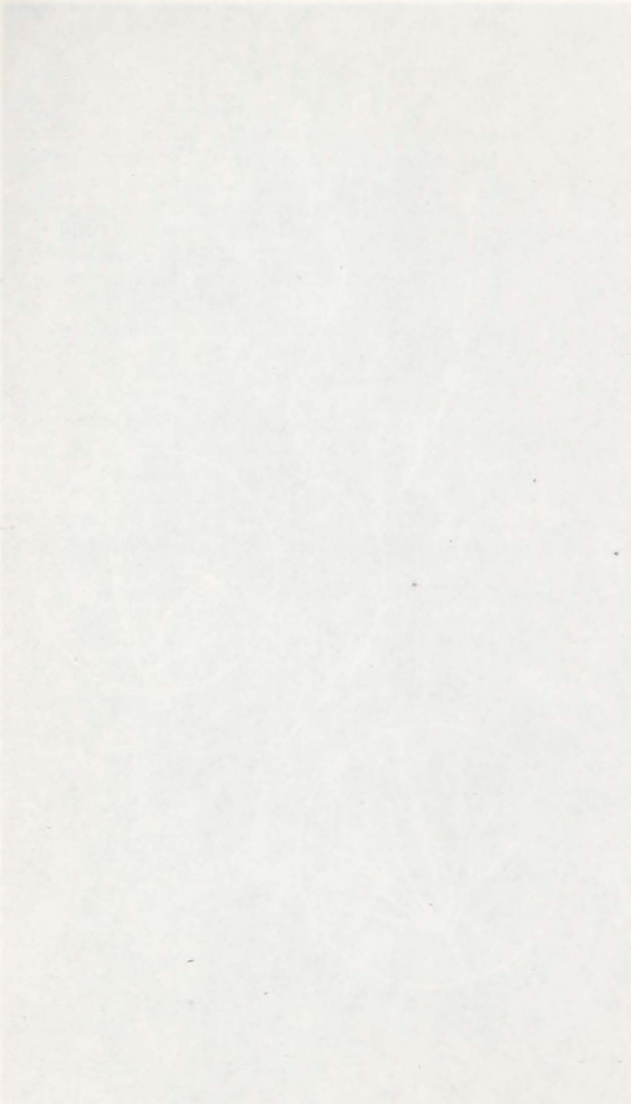
Each internode (stemlike tissue between the leaf whorls) of the stem consists of a single cell in *Nitella*, while in many species of *Chara* the internodal cell is sheathed by a layer of vertically elongated cells of much smaller diameter (insert 1). These sheathing cells give the *Chara* stem a vertically lined appearance, while *Nitella* is smooth.

These plants reproduce both vegetatively and by sexual fruiting bodies. The female body or öogonium (egg-bearing case) is quite conspicuous and its whorl of cap cells differ in number between genera (insert 2). Both the female and male fruiting bodies are borne on the leaf filaments. Vegetative propagation is accomplished by star-shaped aggregates of cells that develop on the lower stem nodes, bulbletlike structures on the anchoring rhizoids, or anchoring structures and outgrowths from the stem nodes.

Many species, especially those of *Chara*, become encrusted with calcareous deposits giving the plant a harsh, rough surface. This calcium carbonate accumulation around the plant may remain intact after death of the plant, giving rise to the name "stonewort" or stone plant.

These plants may present problems in water distribution systems, but seldom become as serious a weed pest as the filamentous green algae. They rapidly become established in small pools and in standing water on new irrigation systems.

Chara spp



FLOATING AQUATIC WEEDS

A number of floating plant pests are known to exist on Western irrigation systems. Some of these plants can survive either completely free-floating or they may root in the bottom mud when growing in shallow waters. Certain species are almost amphibious and will extend onto mudbanks. Fortunately for Western irrigation systems, a few of the very aggressive species will not survive freezing temperatures and occur only in isolated areas in the Western United States. Two of these are waterhyacinth and alligatorweed. These species are illustrated to acquaint the irrigation operator on more southerly projects with them in the event these plants should extend their range.

Duckweed, a very cosmopolitan floating aquatic weed, is included to illustrate a typical plant of this group. A number of plants representing many plant families are true-floating aquatics and do occur on Western irrigation systems, but were not included because of the very limited problems they produce. Some of these species found in isolated areas in the West are waterlettuce, watervelvet, waterprimrose and waterfern. The reader is referred to publications cited in the bibliography for aid in their identification in the event they might be encountered.

DUCKWEEDS

Common Duckweed

Lemna minor L.

Duckweeds are characterized by their diminutive size and lack of stems and true leaves. They are the simplest and some of them the smallest of flowering plants. Duckweeds are free-floating on or slightly beneath the water surface. The plant consists of a leaflike structure, or frond, and in some species a single root that penetrates into the water. The flowers, being inconspicuous and simple in structural form, arise from the edge or upper surface of the fronds. These are seldom seen and some species apparently never flower.

This family of plants has four genera, of which *Lemna* is probably most often seen on irrigation systems where water is static. A typical vegetative habitat of this species is shown, consisting of hundreds of plants covering the surface of very slow moving or quiet waters. *Lemna minor*, as illustrated, is one of the smaller species. A single frond of this plant is about the size of a pinhead. Plants of the *Wolffia* genus have fronds much smaller than *Lemna* and are microscopic in size. They can be detected by the greenish cast they impart to the water surface. Plants in this family propagate vegetatively by proliferous growth of new individuals from the edge or base of the parent fronds. During warm summer months these plants can cover the surface of a pond in a few weeks. The plant overwinters both by seed and vegetatively by a minute bulblet frond that sinks to the bottom of the water body and rises to the surface the following season.

These plants become pests to irrigation systems when they are carried into siphon tubes, trashracks, and pump inlet structures from their still water habitat.


Lemna minor

WATERHYACINTH

Eichornia crassipes Mart.

Waterhyacinth is a native of tropical America and was probably introduced in the United States as an ornamental. As an escapee it has become an exceedingly troublesome species by clogging waterways of the Southern States. Its attractive blue-purple flowers and characteristic bulbous leaf stem with rounded leaf blade make it easy to identify. The plant is usually found floating on the surface of ponds and quiet streams and growing on mudbanks. This plant spreads vegetatively by horizontal stem growth and rooting at the nodes to produce new plants that develop into mats covering large areas. The capsulelike fruits contain many seeds that provide for extensive spread of the species in suitable climates.

Fortunately for Western irrigation systems, this plant is unable to withstand temperatures of Northern latitudes and is only occasionally found in Western States of milder climates. Waterhyacinth has been locally abundant in a few localities in California for a number of years, but has apparently been kept in check and is seldom reported as an aquatic weed in areas of Bureau of Reclamation activity.

Eichornia crassipes

ALLIGATORWEED

Alternanthera philoxeroides Mart.

Alligatorweed is native of tropical regions and has become a serious pest covering extensive drainage and ponded areas in the Southern States. It has been introduced northward, but is not hardy in the Northern States.

This is a spreading weed that forms floating mats over extensive areas sufficiently dense to support the weight of a man. The creeping, branched, prostrate stems are often jointed, and roots form extensively at stem-joints. During low water it will cover muddy banks and lowlands. The linear leaves develop on the stems in an opposite arrangement with smooth or entire margins, and are somewhat waxy in appearance. Flowers are produced in a rounded compact spike. The flower sepals or flower leaves are pale green or whitish, giving the flower spike an overall white appearance.

Like the waterhyacinth, this weed is unable to withstand extended periods of freezing; consequently, it is seldom found on Western irrigation systems. It has been reported to occur in small localized areas of the Southwest.


Alternanthera philoxeroides

EMERSED AQUATIC WEEDS

Many plant pests that root in the aquatic soil and send stems and leaves above the water surface are grouped in this category and are well known to irrigation operators. Some of the species in this group are the first to invade newly inundated lands, especially when the features are intermittently wet or where the water is normally shallow. Backwater areas of reservoirs and drainage canals are especially troubled by these weeds. The cattail and bulrush species, which are illustrated, typify these plants. A number of additional species are known to infest such environments, but vary locally and are too numerous for inclusion in this booklet.

Emersed weeds are especially troublesome to irrigation systems in that they spread rapidly to choke drainage channels, increase silt deposition, interfere with designed operation and maintenance procedures, and waste tremendous quantities of water through natural life processes of transpiration.

CATTAILS

Typha spp

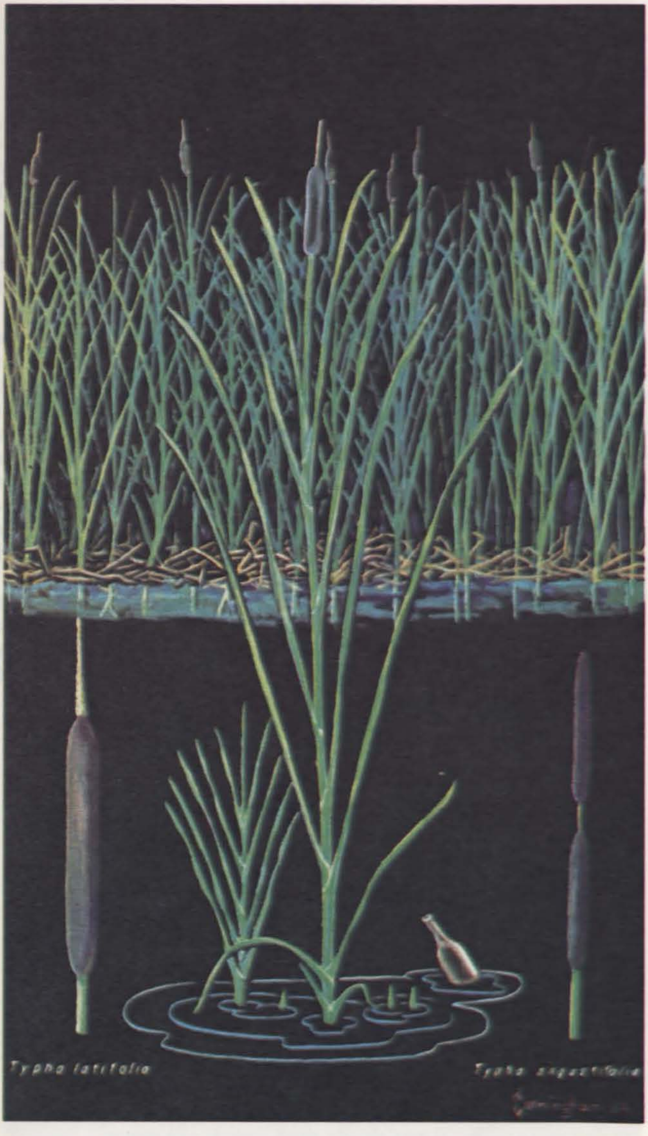
Cattails are widely distributed and are well known. They will invade almost any wet place, being one of the first plants to occupy a newly inundated area. They are quite easily recognized by their growth of stout jointless stems, linear flat leaves, and cylindrical flower spikes. These plants produce fleshy underground stems that will spread a single individual over an extensive area. These underground stems or rhizomes also perform as food storage organs, having a high starch content. The cattail rhizome is readily eaten by aquatic animals, such as muskrats.

The two species most commonly observed are T. *latifolia* L., the common or broadleaf cattail, and T. *angustifolia* L., the narrowleaf cattail. When these two species occur together, a certain amount of hybridization will produce individuals of divergent character.

Identification is readily accomplished by study of the flower spikes, which consist of two portions; the female or pistillate portion of the spike is below, and the male or staminate portion is above. The broadleaf cattail is recognized by its more persistent pistillate or seed-producing flowers, which are on the lower portion of the brown flower spike that is taillike in appearance. The male portion of the flower spike is smaller in diameter, less compact, and soon disappears in midsummer leaving a tapered stem. The narrowleaf cattail, from its common name, is recognized by its more slender leaves and a definite separation that occurs between the male and female parts of the flower spike. This characteristic is clearly seen in the younger flower and becomes less definable as the seeds mature.

Each flower spike will produce hundreds of seeds that are disseminated by air and water over wide areas to spread the species.

Cattails are found on most Western irrigation systems and are especially troublesome in drains and slow-moving water of shallow channels. These plants will spread throughout a drain in a short time, thereby reducing the potential carrying capacity and increasing silt deposition.


Typha latifolia
Typha angustifolia

BULRUSH

Scirpus spp.

The bulrush, or club rush, belongs to the sedge family, *Cyperaceae*. These grasslike or rushlike herbs are generally perennial and rarely annual. They spread vegetatively and overwinter by means of scaly, stout, reddish horizontal stems or rhizomes. These plants are characterized by the cylindrical or variously angled erect stems (technically called culms) and much reduced small leaves that develop near the plant base. Leaves are often overlooked because of their reduced size and clasping nature in some species.

There are numerous species of bulrush, but one of the more commonly observed species is the great or soft-stem bulrush, *Scirpus validus* Vahl, that is often referred to as tule. This species has a soft, easily compressed culm (stem) that is round in cross section tapering upward. The flowers are produced on the terminal of the culms. These stems often grow several feet in height. The leaves are sheathlike at the base of the plant. Accurate identification of the bulrushes requires detailed botanical study to differentiate the numerous species predominantly by means of flower and fruit characteristics.

Bulrush is common to irrigation projects, especially in marsh areas or in shallow drains. Their habitat is similar to the cattail, and they contribute extensively to the marshy vegetation complex that restricts the carrying potential of drainage conveyance channels.

Scirpus spp

WOODY PLANTS

Invasion of woody plants on wet areas of irrigation systems is limited to a few species that tolerate wet or saturated soil areas, at least periodically. Most of these plants are referred to as phreatophytes, which is a term descriptive of plants that obtain their water supply from the soil saturation zone either directly or through the capillary fringe.

Some of the woody weed species that fall in this category are saltcedar, cottonwood, willows, and wildrose. Although this grouping of weed plants deviates somewhat from the scope of true aquatic pests, they are included to emphasize their importance to the irrigator. Saltcedar is the one species that should be correctly identified in case of its invasion of a new area, because of its aggressiveness and apparent increasing range of adaptation in the United States.

TAMARISK OR SALTCEDAR

Tamarix pentandra Pall.

Saltcedar is a deciduous shrub or small tree that was apparently introduced into the United States as an ornamental shrub in the early 1800's. A few species are still widely used as ornamental shrubs. The desert tamarisk or saltcedar, *Tamarix pentandra*, has become an aggressive invader and now occupies extensive areas on streams and flood plains of the Southwest. This species has created many pressing problems because of its rapid spread, producing dense growths that wastefully consume water in arid regions. Invasion of saltcedar has also produced serious problems by clogging floodway channels and increasing deposition of sediments. Saltcedar is considered to be a phreatophyte.

Tamarisk produces small, alternately arranged scalelike leaves (insert 1A) that often become encrusted with salt secretions. The bushlike stems of younger plants are flexible and become brownish-purple as they age. The flowers range from pink to white and are clustered on branched flower stalks or panicles. The fruit is a capsule which may contain a varying number of seeds. The seeds have a tuft of hairs at the apex (insert 1B), which aids in their wide dissemination. Saltcedar seedlings develop rather slowly, although the seeds germinate rapidly when deposited on moist soil. Both the seedling plant and older specimens will survive submergence periods of a few weeks.

Taxonomy of species in this family has been subject to confusion in the past and is still in a stage of research. In general, T. *pentandra* is differentiated from similar species by the number of plant flower parts, particularly by stamens and petals, which are produced in fives (insert 1C). This species is sometimes referred to as five-stamen tamarisk, from which the specific name *pentandra* is derived.

Tamarix pentandra

INVERTEBRATE AQUATIC ANIMALS

In addition to various types of aquatic plant life found in irrigation systems, many small aquatic animals also present problems to water distribution. These animal pests, being of a relatively low order in the animal kingdom and therefore lacking an internal bone structure, are referred to as invertebrate animals. The aquatic animals of this type that create problems for the irrigation operator are submersed during some portion of their life cycle, usually attaching to submerged water structures or burrowing in the bottom mud of canals. Some of these more commonly observed animals are: Bryozoans or pipe moss, fresh-water sponge, larvae of certain aquatic insects, and fresh-water clams.

The problems that *Bryozoa*, sponge, and insect larvae create on irrigation structures are similar in scope to those produced by attached algae. These animals attach themselves to canal linings and other submerged water structures, creating considerable obstruction to waterflow. Also, the *Bryozoa* and sponge are often found growing inside of pipes and enclosed water conduits. The fresh-water clam, while it does not attach to submerged water structures, does under certain conditions grow and develop so prolifically as to reduce the carrying capacity of a canal. Clams reduce the cross-sectional area of a canal by aiding in the rapid development of silt bars on the canal bottom.

General descriptions of some of the typical invertebrate aquatic animals found in irrigation systems are given in the following pages to familiarize the reader with types that may be encountered.

FRESH-WATER SPONGE

There is a single family of fresh-water sponges, the *Spongillidae.* These are simple animals with bodies made up of unspecialized tissue without specific organs, consisting of a maze of interconnected channels, chambers, and orifices. The support or skeleton of the animal is mainly made up of random groups of needlelike siliceous bodies called spicules (insert 1) surrounded by gelatinous masses and sometimes a horny fiber called spongin. Spongin is the material that makes up the body of the commercial marine sponge. The spicule is useful in identifying this animal.

The fresh-water sponge is usually brown or yellowish in color; occasionally the animal has a greenish cast. This green coloration is produced by the unicellular algae that exist in the many chambers and channels of the sponge body and provide a food source for the animal. Water containing food materials is circulated through the many pores of the sponge by movement of threadlike projections or flagella.

The size of the fresh-water sponge is variable, depending on location and species. The sponge may be merely a slimelike or delicate mat becoming encrusted with the numerous outgrowths and branches; or, when new animals grow from year to year over the old, dead skeletons, the encrustation may attain considerable size.

The animal is able to regenerate with a few cells, often overwintering in a perennial habit. The fresh-water sponge produces a highly resistant resting body, or "gemmule" (insert 2), that is quite similar to the "statoblast" of *Bryozoa.*

These animals are often found growing in clear, still water, and are being reported with increasing frequency as attached (sessile) growths in lined irrigation canals.

Sponges in irrigation systems can cause considerable hydraulic problems when growing in association with other aquatic animals and plants. This undesirable effect is compounded by the favorable substrate they create for invasion of a wide variety of other aquatic pest organisms.


1
FRESH WATER SPONGE
2
Cunningham '64

PIPE MOSS

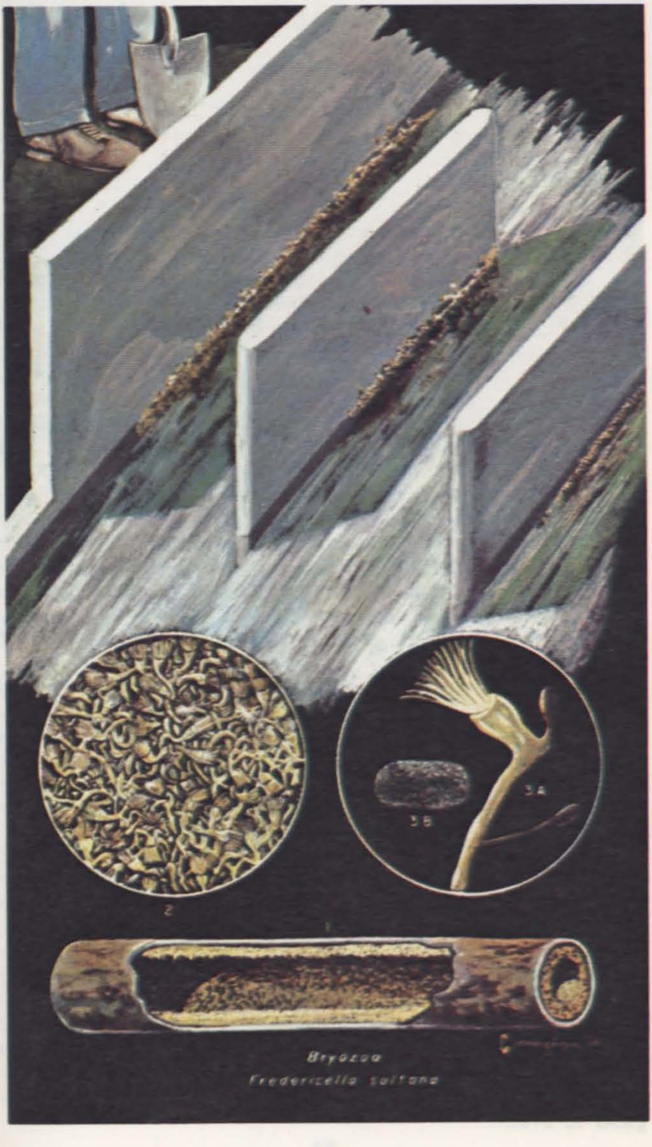
Bryozoa

The fresh-water *Bryozoa*, or "pipe moss," are a group of invertebrate aquatic animals that are often mistaken for a mat of dead moss. Colonies of these animals are plantlike in appearance except for their coloration, which is brownish-white. *Bryozoa* attach to logs, rocks, and other submerged objects, usually where the light is relatively dim. They have been found on a number of irrigation systems growing in profusion on concrete canal linings, submerged inlet screens, louvers, trashracks, and on the inside of pipes (insert 1). The individual animal is microscopic, more or less cylindrical with a thin body wall. These animals secrete a thin protective layer about the body wall. Many of the individual animals grow in close association with one another to produce a connected, highly branched, antlerlike colony (insert 2). The protective coatings of these colonies of animals are the most conspicuous feature, being massive and tough, or delicate and gelatinous, depending on the species. Oftentimes, young colonies continue to grow on the remaining protective layers of the dead animals, thus producing a thick mat on a solid substrate.

The individual animals feed on various microscopic plants and animals that are swept into the animal's digestive system by a crown of tentacles. The tentacles when extended have the appearance of tiny delicate flowers (insert 3A). A slight disturbance in the proximity of the animal will cause it to retract the tentacles in a flash. Most bryozoan colonies are stationary, but a few species are capable of sluggish movements. The colony can grow asexually where a portion of the body wall grows outward to produce a new animal.

A unique feature of the *Bryozoa* is their ability to produce a highly resistant body called a statoblast or sessoblast (insert 3B). This seedlike body develops from asexual budding. This structure provides for the species to be carried over during unfavorable environmental conditions and for geographical disseminations.

Bryozoa growing on submerged water structures and in conduits have been known to create serious hydraulic problems for water distribution structures. Two bryozoan species known to infest Bureau of Reclamation irrigation systems sufficiently to become problems are *Plumatella repens* L. and *Fredericella sultana* Blumenback. The latter species is illustrated.


3A
3B
2
1
Bryozoa
Fredericella sultana

FRESH-WATER CLAM—ASIATIC CLAM

Corbicula fluminea, Muller

The fresh-water clam, or mussel, is quite extensive throughout inland waters of the United States. Species range from a fraction of an inch to many inches in length. Many species have some commercial value, while others are troublesome pests.

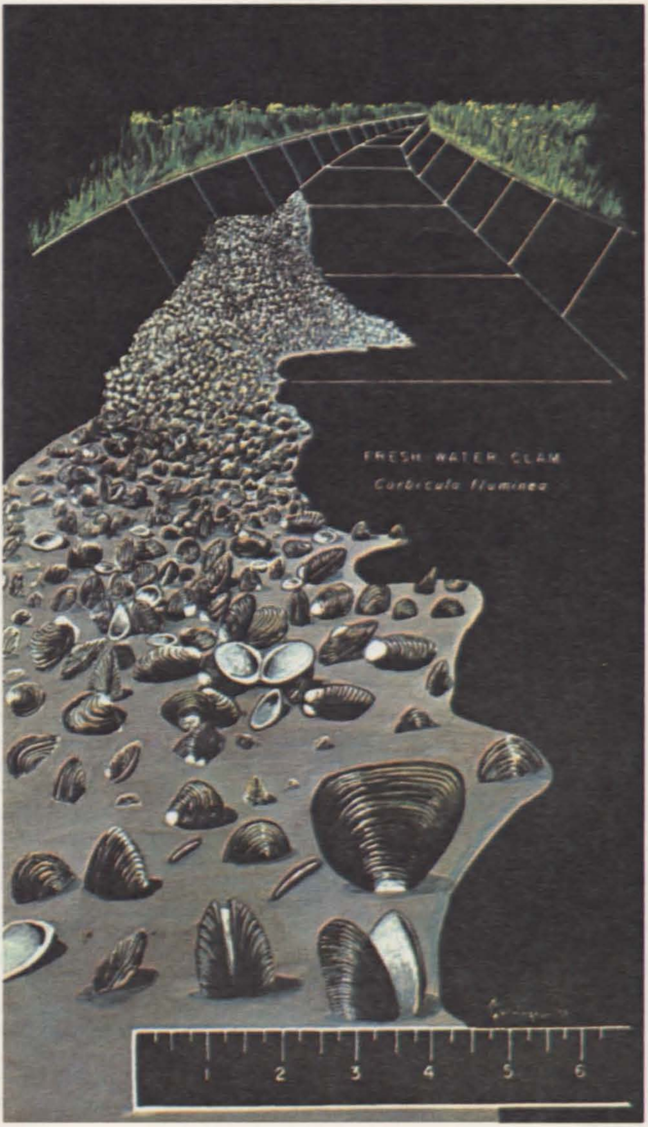
The Asiatic clam, *Corbicula fluminea*, is a species that has caused problems in irrigation systems in the Western United States by fouling pumps and inlet screens, plugging tubes of heat exchange devices, and reducing the carrying capacity of canals and conduits. These organisms have been reported in numerous areas of California, Arizona, and the Pacific Northwest; and some species of this genera are rapidly spreading into fresh waters of the Eastern United States.

Members of the *Corbicula* genus are easily recognized by the distinctive concentric sculpture of the outer shell; but they are often overlooked until the population becomes dense, because of their habit of burying in the bottom mud. Some shells are thin and easily crushed while others are very thick. The shells of these animals are divided in halves or valves that are securely attached to each other by an elastic hinge. Under natural conditions, the valves open slightly to allow protrusions of the muscular foot at the lower margins of the shell. This foot provides for sluggish locomotion of the animal.

The animal feeds on microorganisms which are drawn into the body cavity by an incurrent siphon. Wastes are excreted through a similar or excurrent siphon. These siphons can be seen barely protruding above the mud surface when the animal is feeding. During periods of disturbances or unfavorable environmental conditions, the animal will tightly close its shell halves and often bury itself deep into the soil.

The species is reproduced by development and hatch of fertilized eggs within the adult clam. Individual clams may release thousands of microscopic larvae, which soon take up residence on the bottom strata. Little is known of the exact duration of the spawning season, which occurs chiefly in the summer months with a number of generations being produced in one season.

A typical silt bar heavily infested with clams and remanent shells, as might be seen in a canal, is illustrated. The shells of Asiatic clams range from 1½ inches up to 2 inches in diameter when mature and vary in shape from somewhat triangular to oval.


FRESH WATER CLAM
Corbicula fluminea
1 2 3 4 5 6

BLACK FLY

Simulium spp

These insects belong to the family *Simuliidae*, a small family which is classified in the fly order *Diptera*. The importance of this insect to the hydraulic factors of irrigation systems involves the pupal encasements, or cocoons, that are laid down on submerged canal and flume linings. These slipper-shaped encasements create extensive areas of roughened surfaces that increase resistance to waterflow in a canal.

The adult fly is a small gnatlike insect that is seldom more than $\frac{3}{16}$-inch long, varying in color from gray-brown to black (insert 1). These insects are completely aquatic in all stages of their life cycle, except the free-flying adult which may be present in some areas in such great numbers as to be almost unbearable to a visitor. The "black fly," "buffalo gnat," or "no-see-ums" is well known for the persistent manner in which the female pursues and bites warm-blooded animals.

In its life history, the adult fly deposits eggs on vegetation or other solid substrate just under the surface of swift water, especially where the current is broken. Overwintering sometimes occurs in the egg state. The eggs hatch below the water surface to produce larvae which attach themselves to a solid submerged substrate. The larval stage may last from 2 to 6 weeks. During the last stage of development, the larvae construct silken cocoons in which the insects develop into pupae, a growth stage preceding development and emergence of the adult. The cocoons are firmly cemented to the substrate and may be in the shape of a pocket, slipper, or vase (insert 2). This is the growth stage that creates roughened surfaces on a canal lining. The pupae (insert 3A) are oval and enlarged at the upper end, and are yellow to red-brown in color. They have small abdominal hooks by which they remain attached to the cocoon (insert 3B). At the head end are two groups of long branched filaments extending out of the cocoons that perform as respiratory organs. The pupal stage usually lasts from 2 to 8 days prior to emergence of the flying adult. The pupal cases generally are quite persistent following emergence of the adult insects, and often require mechanical removal from canal linings.

Identification of the genera and species of these insects is somewhat difficult, usually requiring detailed study of various portions of the insect body. These insects are widespread, but have been reported most commonly on irrigation structures in the Northwestern and the Rocky Mountain States.


2
3A
3B
BLACK FLY

BIBLIOGRAPHY

FASSETT, N. C., "A Manual of Aquatic Plants," McGraw-Hill, 1940, 382 pp.

FERNALD, M. L., "The Linear Leaved North American Species of *Potamogeton*," Memoirs of the American Academy of Arts and Sciences, vol. 17, part 1.

FERNALD, M. L., "Gray's Manual of Botany," eighth edition, American Book Co., 1950, 1632 pp.

INGRAM, W. M., and A. F. BARTSCH, "Animals Associated with Potable Water Supplies," Operators Identification Guide; American Water Works Association Manual M7, 1960, 31 pp.

MASON, H. L., "A Flora of the Marshes of California," University of California Press, 1957, 878 pp.

MATSUMURA, Y., and H. D. HARRINGTON, "The True Aquatic Vascular Plants of Colorado," Technical Bulletin 57, Colorado Agricultural and Mechanical College, 1955, 129 pp.

MUENSCHER, W. C., "Aquatic Plants of the United States," Comstock Publishing Co., Inc., 1944, 374 pp.

PENNAK, R. W., "Fresh-Water Invertebrates of the United States," The Ronald Press Co., 1953, 769 pp.

PRESCOTT, G. W., "Algae of the Western Great Lakes Area," Cranbrook Institute of Science, Bulletin No. 31, 1951, 946 pp.

SINCLAIR, R. M., "Clam Pests in Tennessee Water Supplies," Journal of American Water Works Association, vol. 56, No. 5, 592–599.

SMITH, G. M., "The Fresh-Water Algae of the United States," second edition, McGraw-Hill, 1950, 719 pp.

WHIPPLE, G. C., revised by G. M. Fair and M. C. Whipple, "Microscopy of Drinking Water," John Wiley and Sons, fourth edition, 1954, 585 pp.